2010 RESEARCH TOPICS FOR PROJECT PRIORITIZATION

1. Aggregates and Geotechnical

1.01. *Low Cost Rural Road Surface Alternatives* – Paul Wiegand, Iowa State University

OBJECTIVES: To develop guidelines for proper use of Portland cement in the stabilization of roadways carrying 100-400 vpd to resist freeze thaw action; also, to be the first stage of a program for the application of rigid or flexible pavement structures in the road's future as traffic and funding allow. Objectives:

- Develop a matrix of soil types, stabilization depths, and required cement addition amounts and traffic volumes of 100-400 vpd. If possible select some surfaces with varying amounts of truck or other heavy traffic also. Select the type of surface that will be applied to each roadway after incorporation of the cement and soils. In addition, develop methods of measuring the performance of the improved base and surface.
- Monitor construction of multiple projects and/or multiple test sections within a few projects to relate the variables to performance.
- Monitor performance on a biannual basis (spring and fall) for at least five years. Also monitor traffic counts and distributions by vehicle types over the test period.
- Develop a guidelines report on using Portland cement as an intermediate means of providing a stable platform to resist spring thaw and frost action and provide stage one for development of a rigid or flexible pavement to be placed as traffic increases and funding is available.

Time Estimate: 6 years
Cost Estimate: $300,000 (research only, does not include construction)

1.02. *Optimizing Pavement Base, Subbase, and Subgrade Layers for Cost and Performance on Local Roads* – CP Tech Center, 2010 Iowa Research and Technology Transfer Committee

Historically, most county and city pavements have been constructed on natural subgrade with little or no consideration given to bound or unbound support layers. With the need to minimize the investment of public funds and maximize performance, guidance is lacking on how to optimize the pavement system for performance and cost.

The tasks to be addressed under this project would include conducting literature reviews and forensic evaluations of local roads with particular attention to sections containing stabilized and granular subbases and poor soil conditions where stabilization materials were used. Using this actual performance data, guidelines would be developed for various traffic, soil, and pavement factors for optimized performance and cost of concrete pavements. Of particular interest is the estimated increase in pavement life received from granular subbases and stabilized subgrades in association with cost over the life of the pavement. Life cycle cost analysis will be completed for treated and non-treated subgrades and subbases.

Time Estimate: 24 months
Cost Estimate: $150,000

1.03. *LRFD Design of Drilled Shafts* – Sri Sritharan, Iowa State University

Deep foundations are typically used to support bridges in Iowa with the driven steel H-piles being the most preferred choice of pile foundations. However, steel H-piles are not the most cost effective foundation solution under all soil and construction conditions. Cast-in-place drilled shafts provide an alternative deep foundation solution and they can be cost competitive because they are relatively easy to construct in firm soils, within divided highway medians, adjacent to existing structures, and may not require design and construction of pile cap or pile-to-cap connections.

In order to make the drilled shaft foundation option equally competitive to driven pile foundations, regional resistance factors suitable for the Load and Resistant Factor Design (LRFD) of drilled shafts should be developed. In addition to providing cost effective deep foundation options for bridges in Iowa, this process will also help satisfy the mandate issued by the FHWA to use the LRFD approach on all new bridges. With Iowa DOT funding there is currently a project underway to build a drilled shaft database of completed static load tests from Iowa and other states.

OBJECTIVES: The overall objective of this study is to examine and improve the drilled shaft design (in accordance with LRFD) and construction procedures used in Iowa, thereby increasing the cost effectiveness of this foundation type.

Goals will be achieved by:
- Completing a comprehensive literature on the design of drilled shafts
- Analyzing the collected drilled shaft test data and calibrate LRFD resistance factors for various static analysis methods
- Verifying the calibrated resistance factors using two to four static load tests on instrumented drilled shafts installed in suitable sites preferably with shallow bedrock in accordance with the Iowa DOT Bridge Design Manual
- Finalizing the LRFD resistant factors for design of drilled shafts in Iowa
- Demonstrating when the drilled shaft option will be cost-effective over driven H-piles in practice

Cost Estimate: $240,000

1.04 *Improved Method for Belowground Cable Installation Along Roads and Highways*: *Buried Duct Network* (BDN) – Dr. Lawrence M. Slavin, Outside Plant Consulting Services, Inc.

Present buried construction procedures for utility distribution cables (telephone, CATV, electric power) typically do not allow for convenient future upgrade or replacement of the initially installed lines. The shortcomings of such conventional direct-buried construction methods can lead to road damage or safety problems, including risk of gas or power line hits during reconstruction activities.

The proposed *Buried Duct Network* (BDN) represents a departure from conventional direct-buried construction methods for utility lines (telephone, CATV, electric power) in which cables are placed in a trench along the local distribution route. The BDN is a hybrid, joint-use construction method, combining the upgrade features of underground conduit systems with the cost advantages of direct-buried cable installation. This proposed method of construction, and associated hardware, allows for convenient, safe placement of new cables. The BDN therefore encourages and supports the installation of belowground utilities, minimizing future construction

difficulties and hazards, helping minimize the future proliferation of undesirable pole lines. Potential applications include new roads or widening under federal, state, or local jurisdiction, as well as residential applications for which utility cables are placed along the right-of-way (ROW).

The BDN has been developed with the cooperation of the Center for Underground Infrastructure Research and Education (www.cuire.org), based at the University of Texas at Arlington, and was supported under the SBIR (Small Business Innovative Research) program for the U.S. Department of Transportation, performed under Phase II contract number DTRT57-07-C-10046. This R&D effort was solicited under DTRS57-04-R-SBIR (Ref. 04-FH2 **"**Equipment for Undergrounding Utility Lines at Lower Cost".

The present proposal focuses on technology transfer of the BDN by working closely with the Iowa Department of Transportation to help incorporate improvements in Iowa DOT utility accommodation guidelines as relate to the installation of cables along state roads and highways, as well as to help implement such improvements during actual road projects.

2. **Pavement Management / Engineering Data Collection / Data Studies**

2.01. *Risk Control for Highway Bridges* – M. Elhakeem, The University of Iowa

Performance of highway bridges can be affected by natural disasters such as floods and major storms, in addition to hazards including negligence and improper maintenance, collisions, acts of vandalism, and terrorist attacks. There is a need to assess the actual risk corresponding to the ultimate limit states (ULS), serviceability limit states (SLS), and extreme events including terrorist acts. The target reliability depends on: consequences of failure and a unit cost of the reliability. The consequences can be very different for different limit states. In general, they are orders of magnitudes lower for SLS than for ULS. In AASHTO LRFD Code (2004), the reliability is controlled by load and resistance factors. In addition, nominal (design) values of loads can be different depending on the considered limit state. However, the code specifies return periods in a rather arbitrary manner. For other limit states and extreme events the return periods are not mentioned. There is need to establish procedure for a rational selection of design loads and effects from floods on bridge structure and pavement conditions across bridge crossings with corresponding return periods.

The objective of the project is to develop a rational approach to risk control for bridges involving:

- Development of risk analysis procedures for assessment of the actual risk
- Development of selection criteria for the acceptable risk levels (target reliability)
- Development of risk control mechanisms for implementation in practice

2.02. *Improved Pavement Forecasting Models for Repaired/Rehabilitated Pavement Sections in Iowa* – Halil Ceylan, Iowa State University

When pavements are rehabilitated, the current pavement condition rating (PCR) system assigns a rating of 100 to new/under construction sections, based on a scale of 0 to 100. However, some pavement sections' condition deteriorates much faster than others, depending on the repair treatment applied and the condition prior to repair. Therefore, average PCR values in a single year may be misleading if many "band-aid" repairs are performed. True cost-effectiveness should be determined based on long-term performance. The proposed study will also determine the best initial rating for the repaired section taking into account the age and condition of the pavement being repaired and the specific repair treatment applied.

OBJECTIVES:

- Develop models to forecast future pavement conditions using data available to Iowa DOT
- Determine remaining service life of pavement sections based on forecasted condition
- Develop decision trees for selecting rehabilitation strategies based on estimated remaining life of pavement sections
- Determine an appropriate initial PCR rating for a rehabilitated pavement section

The results of this research will provide 1) an improved methodology to determine the PCR rating for repaired/rehabilitated pavement section in Iowa; 2) calibrated prediction models that can predict a pavement section's future condition and estimate its remaining life, with or without rehabilitation, based on data available to Iowa DOT. These models may be embedded in the existing Iowa DOT Pavement Management Information System (PMIS) database; 3) a set of decision trees derived from the analysis of remaining lives of pavements for a given set of repair strategies; and 4) an integrated needs assessment process that determines the repair treatment and corresponding funding needs for pavements.

3. **R.O.W. & Roadside Management**

3.01. *Evaluation and Rating of the Effectiveness of Temporary Erosion and Sediment-Control Measures in Iowa Conditions* – Marian Muste, The University of Iowa

There are numerous design specification manuals regarding erosion and sediment control measures (ESCM), but evaluation of their effectiveness in practical conditions is scarce. A survey of Iowa County engineers conducted in 2002 (IHRB TR-464, "Erosion Control for Highway Applications") revealed that field engineers have difficulties in selection of ESCMs because of the lack of information on effectiveness.

This pilot study will construct typical ESCMs and test effectiveness. Selected ESCMs will be implemented at a highway construction site and monitored for effectiveness in limiting erosion and sedimentation control.

The selection will include at least silt fence, seeding, rip rap, matting, ditch checks and mulch. The ESCMs will be monitored over one year to include all seasonal hydrological conditions. Effectiveness will be estimated by their capabilities to retain sediment in same geomorphological and hydrological conditions and ranked.

Time Estimate: 24 months

3.02. *Optimization of Snowfence Design for Iowa Conditions* – Marian Muste and George Constantinescu, The University of Iowa

Blowing and drifting of snow presents a major transportation efficiency and road safety concern, creating hazardous driving conditions which increase the probability of accidents. Also, the additional road maintenance resources needed to mitigate the snow trap problem result in a high increase of snow removal and road maintenance costs for states like Iowa where strong winds and large quantities of snow are recorded during winters.

OBJECTIVES:

- Review existing methods that can be applied to conditions that are typical for Iowa roadways
- Identify sensitive highway areas in terms of weather conditions and typical designs of snow-fences in the state of Iowa
- Optimize design of snow-fences for typical conditions present on Iowa roadways using a systematic procedure based on a numerical approach in which three-dimensional turbulent airflow fields will be computed for different positions of the fence/barrier relative to the roadway and heights of the fence given a certain dominant range of wind directions. The model will account for the relative porosity of the passive snow-control structure
- Compile a design guideline for optimization of design for passive snow-control measures and make recommendations for drift control measures used by Iowa DOT
- Provide guidelines used to develop a design aid tool for implementation purposes.

Time Estimate: 24 months

3.03 *The Effect of Tall Vegetation on Blowing and Drifting Snow* – T. Papanicolaou, C Wilson, J. Buckholtz, M. Elhakeem, The University of Iowa

Tall vegetation increases resistance and minimizes drifting of snow. Therefore, placing tall vegetation near highways has beneficial effects in keeping these highways clean from blowing snow and minimizes loss of life.

This project will develop a model to determine the efficiency of tall vegetation in terms of height, in-between spacing of plants, and location. Based on this model, we will determine the number of vegetation needed for typical Iowa snowstorms and wind velocities. The analysis will be performed numerically and in a wind tunnel.

4. **Hydraulics, Hydrology & Drainage**

4.01. *Low Impact Design Practices BMPs Pollutant Reduction* – Rebecca Kauten, Iowa DNR

The State of Iowa lacks consistent, uniform methods for determining pollutant reduction levels of infiltration-based urban stormwater treatment practices. As a result, the true total cost of investment in low-impact design practices as best management practices (BMPs) cannot be

accurately measured. By gathering data on two innovative road design projects, planners and designers may better estimate the "true cost" of such innovative design compared to traditional practices and maintenance. This information could be used to further develop technologies related to diagnosing, treating and maintaining urban stormwater treatment systems in the Midwest.

The overall goal is to develop a comprehensive, universal water quality monitoring program that generates consistent, uniform data that can be analyzed, compared and interpreted for both local and statewide decision making and resource allocation. By concentrating on low-impact design projects already underway, this project will leverage existing investments and partnerships and provide quantifiable data to further determine initial and long-term performance and maintenance costs and benefits of specific practices.

In-kind support will be provided by Iowa DNR Monitoring Section, the City of Dubuque and Dickinson County. These and other local agencies will also contribute financial support for equipment and other site-specific needs for the project. Iowa DNR would serve as the principal administrative body for the project, with local contacts as implementation support.

4.02. *Evaluating Roadway Subsurface Drainage Practices* – C. Wilson, C. Swan, T. Papanicolaou, M. Elhakeem, The University of Iowa

This project's purpose is to:

- Evaluate the difference in drainage efficacy of edge-drains compared to centerline drains for highways and roads, paved or unpaved
- Evaluate the benefits of subsurface drainage and determine the benefits of draining only low points in the road profile
- Evaluate the effect of increased amount of crushed concrete in aggregate base and shoulder on drain performance with respect to possible plugging by concrete constituents
- Evaluate an electromagnetic inductance method for non-invasively measuring soil moisture within roadway base and sub-grade materials
- Use statistical analysis and flow models to develop drainage design standards

4.03. *Riverbed Scour and Deposition Monitoring Plan for Floods Using a Multibeam Hydrographic Survey System* – Douglas Schnoebelen, The University of Iowa

To ensure the well-being and safety of the public during a flood, major decisions often need to be made quickly with the best data available. In addition, post flood there is a critical need to evaluate changes in channel morphology and bathymetry, and potential scour that may have occurred. During the initial phase of the project, baseline bathymetric maps will be created for priority structures identified by Iowa DOT. This will enable the Iowa DOT to have critical bathymetry maps and a pre-flood understanding of geomorphology and hydrology already in place for rapid evaluation both during and after a flood.

In addition, the initial data will provide valuable data modeling for projects that may be constructed. Future phases of the project might include a flood plan for bathymetric mapping during a flood and post flood comparison. Additionally, another component of the work might compare data from the multibeam to work currently performed by divers. The work could take a phased approach for each component.

IIHR-Hydroscience and Engineering (IIHR) has recently acquired a state-of-the-art multibeam hydrographic survey system and successfully mapped scour near the Highway 65 bridge on the

Des Moines River (2008 flood) for the Iowa DOT. The multibeam sonar can document the geomorphic process occurring (showing details such as ripples on top of sand dune) and accurately create a three dimensional rendering of bedforms, scour, and effect on structures.

4.04. *Hydraulics Evaluation of Various Methods for Deflecting Debris From Bridge Piers* – Dave Claman, Iowa Department of Transportation, Office of Bridges and Structures

Debris accumulation on bridge piers is an on-going national problem that can obstruct the waterway openings of bridges and cause significant erosion/scour to stream banks and abutments. In some cases, the accumulation of debris can adversely affect the operation of the waterway opening or cause failure of the structure. In addition, removal of debris accumulation is difficult, time consuming and expensive for maintenance programs.

There are many publications and products available that deal with mitigating the accumulation of debris on bridges. The suggested research would involve a literary search of all publications, products and pier design recommendations that provide a cost effective method to mitigate debris accumulation on bridges. In addition to a literary search, the project should include a survey of other DOT's to determine what types of debris deflectors they have implemented and the overall satisfaction and performance of those methods.

It is anticipated that one or more cost effective debris deflector methods will be recommended as part of the Phase I research. Once a cost effective method for mitigating debris on bridges is determined, it is anticipated that several bridge locations would be identified during Phase II of the research. The construction of several debris deflection methods will allow field evaluation and performance over time for potential implementation on other bridges throughout the State that experience debris problems.

Cost Estimate: $20,000

4.05. *Determining Entrance Loss Coefficients for Twin Pre-Cast and Triple RCB Culvert Designs* – Marian Muste, The University of Iowa/IIHR

Currently the Iowa DOT uses Cast-in-Place (CIP) Twin and Triple RCB's with standard flared wingwall designs. There is increased interest in constructing Pre-Cast (PC) Twin and Triple RCB's. The difference in the geometry of the standard flared wing walls for Twin or Triple Cast-in-Place RCBs from the straight Pre-Cast culverts results in a difference in entrance losses. In the case of single wing wall configurations, wingwalls conduct the flow directly into the barrel, reducing contraction losses at the entrance. For the same configuration with multiple barrels, there is minimal contraction loss for interior barrels so losses are much lower. Thus, a multiple barrel system should perform better than the same number of single barrels. Estimating this difference in entrance losses is critical to provide appropriate design for newly built pre-cast culverts.

A major problem with current analysis programs for sizing box culvert structures (HY-8 and others) is that they do not analyze multiple barrel box culverts correctly. These programs model multiple barrel structures as though each barrel is a separate single box with its own wingwalls. Multiple barrel structures, however, share a single set of wingwalls. Most box culverts fall in this category of multiple barrel structures with a single set of wingwalls. Given that available guidelines and experimental studies of entrance losses for culverts are limited to single barrel culverts, we propose a physical modeling study to determine entrance losses for Pre-Cast Twin and Triple RCB's designs. In addition, we would like to compare the velocities and shear stresses

associated with a straight vs. flared wing wall. This could determine if a certain configuration provides better dissipation of the energy to mitigate potential erosion/scour at the inlet or outlet of a box culvert. In order to optimize the designs of both types of box culverts, the effects of the span-to-rise ratio, skewed end condition, and optimum edge condition should also be determined.

Time Estimate: 24 months
Cost Estimate: $185,000

4.06. *Hydro-Enforcement of LiDAR-Derived Stream Centerlines Using County Bridge and Culvert Databases* – Jim Giglierano, research geologist, Iowa DNR/Iowa Geological and Water Survey

After the massive floods of 2008, the state of Iowa allocated $15 million to update and complete floodplain maps for the entire state over the next 5-7 years. The DNR's floodplain mapping program will create new floodplain boundaries using hydrologic models incorporating stream centerlines extracted from high-resolution digital elevation models (DEMs) developed from the statewide LiDAR data collection. The LiDAR DEMs must have all barriers to water flow removed prior to extraction of the stream drainage networks using a process called hydro-enforcement. This includes removing from the DEMs all bridges crossing streams and culverts under roads and driveways. Information on bridges and culverts resides in several local and state government offices as paper files, maps and electronic databases and spreadsheets. The subject of this research is how to inventory, digitally capture, store and manage the records, and incorporate them into the hydro-enforcement/stream delineation process leading up to the hydrologic modeling of floodplains. Objectives include:

- Inventory county engineers for bridge and culvert records, databases and maps–examine how data differ from office to office regarding number of features, type, material, length and diameter, and location information.
- Design a GIS database schema for culvert and bridge records that will meet the needs the accuracy and attribute needs of hydrologic modeling of floodplains, as well as future uses by local and state entities.
- Research optimum methods for the collection and digitizing of county engineer records into the GIS database and perform collection for selected test counties in consultation with the floodplain mapping program.
- Research methods for incorporating GIS databases of culverts and bridges into the hydro-enforcement process and test accuracy and versus other methods.
- Research methods to capture and maintain bridge and culvert databases using online web-based technologies
- Research other uses and benefits of bridge and culvert GIS database to local and state entities.

Time Estimate: 12-18 months
Cost Estimate: $125,000 - $150,000

4.07. *Investigation of the 1993 and 2008 Flood Over-Toppings Effects on Bridge Abutments and Development of Specific Protection Measures* – George Constantinescu and Marian Muste, The University of Iowa

It is common during flood flows for embankment approaches to bridges to be over-topped by flood waters. This situation occurs often for small, rural bridges. While such over-topping may ease flow constriction through the bridge opening, there is substantial evidence that over-topping may erode the embankment, or locally aggravate scour at the abutment. Presently, there is little information regarding the effects of over-topping on scour development and embankment erosion.

OBJECTIVES: A survey of the overtoping cases and other abutment scour effects as a result of historical floods in 1993 and 2008 will be conducted to capture commonalities of failure characteristics. The study would document cases of over-topping with a particular focus on cases corresponding to designs and conditions that are most common for Iowa bridges.

Controlled laboratory tests will be conducted together with three-dimensional numerical simulations of turbulent flow fields to describe how over-topping affects scour development and embankment erosion. Tests will also investigate means to protect against erosion caused by over-topping and guidelines for implementation of these scour protection measures will be developed.

Time Estimate: 24 months

4.08 *Incorporating Bridge Guard Rail Hydraulics for Floodplain Analysis & Backwater Effects* – T. Papanicolaou, M. Elhakeem The University of Iowa

The use of certain bridge rails with large height or minimal open space may adversely impact the surrounding floodplain. Typically the geometry of the bridge rails is not considered when conducting floodplain analysis.

OBJECTIVES: To provide a method for incorporating the hydraulics of various bridge railing systems on a bridge structure and determine the impacts on the surrounding floodplain during flood events. Therefore, a mathematical model used to characterize the hydraulic performance of bridge rails will be developed, and the use of this model in floodplain mapping software such as HEC-RAS will be outlined. The proposed rating curve model will be used to determine the effects of the submergence of bridge rails by an increase in downstream water surface elevation.

4.09 *Pilot Project for a Hybrid Road-Flooding Forecasting System on Squaw Creek* – Witold Krajewski, Anton Kruger and Ricardo Mantilla, The University of Iowa /Iowa Flood Center and IIHR

According to the National Weather Service, more than half of the fatalities attributed to flash floods happen when people are swept away in vehicles while trying to cross a flooded intersection. In an ideal situation, every road-river intersection could be monitored in real time on a continuous basis using electronic stream-level measuring devices, however, this is impractical since every ten miles roads intersect, on average, five streams that can potentially flood. A network of thousands of such monitoring devices would be necessary to create a reliable system. On the opposite end of possibilities, a distributed flood forecasting mathematical model capable of highly accurate predictions (i.e. errors in the order of 1%) could replace the need for an observations network by making flood predictions at all intersections of roads and streams in a river basin. However, the level of accuracy of current hydrologic models is much lower (~ 50% error) precluding their use as a sole warning tool for road flooding.

OBJECTIVES: The Iowa Flood Center proposes a two-year pilot project for the design, implementation, and evaluation of a hybrid flood forecasting system that combines real-time stream level observations with a state-of-the-art distributed hydrologic model called CUENCAS. The observational component of the system will consist of the strategic deployment of 50 inexpensive stream-level sensing devices that use ultrasound technology to measure the distance from under bridge decks to the stream water surface (device already developed by the IFC). The hydrologic model provides a faithful representation of the waterways in a river basin and does not rely on calibrated parameters. However, it depends on the accurate description of travel times along the channels of river networks. Simultaneous measurements or peak flow arrival times at

50 locations made by the network of instruments serve to improve the reliability of peak flows and times-to-peak at locations where instruments are not available. The model also requires rainfall input already generated in real time by the IFC based on NEXRAD radars data.

BENEFITS: Initial estimates indicate that two years of continuous monitoring of flooding events would improve the hydrologic model reliability as much as a 50-year record at a single location would for a calibrated lumped model, with the benefit of predictions at every location in the basin and not only the basin outlet. When complete, the system will demonstrate a new tool that can be used to provide accurate predictions in real-time of flooding potential for each and every road/stream intersection, both gauged and ungauged, in any Iowa river basin. The system will lead to improved flood forecasting along the main waterways in the state.

Time Estimate: 24 months
Cost Estimate: $315,000

4.10 *Update of Drainage Areas of Iowa Streams (the Red Book) using LIDAR data and GIS* – Ed Engle, Research and Technology Bureau, Iowa DOT

The Iowa Highway Research Board (IHRB) funded a project in 1957, HR-29 Drainage Areas of Iowa Streams. This reference is still used by the Iowa DOT and counties and cities in Iowa for designing bridges and culverts. With newly available LIDAR data for the entire state available along with the current hardware and software resources available for geographical information systems (GIS) it is now time to update this venerable book.

BENEFITS: The proposed project would prepare a reference similar in content to the original but provide greater accuracy and interactivity. To make the information available to a broad spectrum of users, the data and maps should be available in Adobe PDF format as well as with links from maps to a spreadsheet containing all of the data, and a GIS shapefile with all of the information.

5. **Materials**

5.01. *Evaluation of HMA Sampling Procedures* – HMA Research Forum

Previous Iowa DOT studies determined that sampling HMA behind the paver was the best practice. There are a number of sampling procedures used around the country. The proposed research would identify the best three or four procedures used in the north-central region. All the selected sampling methods would be used on a diverse group of projects to determine their ability to detect production variability.

This study would determine what methods detect production variability without increasing sampling variability, and which methods reduce paving delay and sampling resources/time.

Time Estimate: 18 months
Cost Estimate: $150,000

5.02. *Preventing Random Cracking Through Proper Design and Concrete Mixes* – National Concrete Pavement Technology Center Research Committee (NCPTC)

The composition of concrete materials has changed over time, with new additives introduced and construction periods accelerated. Random cracking has increased in concrete pavements at a very early age. In some cases this has manifested itself in spalling near transverse joint or random longitudinal and diagonal cracking in new slabs. Often the cracking occurs before the pavement is open to traffic. These cracks are random on individual projects and within a given project. A need exists to examine the identified projects for one or more common causes of the distress and to consider ways to alleviate them in the future.

The new Mechanistic-Empirical Pavement Design Guide (MEPDG) utilizes material characteristics of all concrete materials to predict a given joint spacing for a given depth of pavement. A truly mechanistic design requires that the impact of materials must be reflected in the design cross section and jointing pattern.

Phase I –Problem Identification - Survey of the state and county concrete pavements (6 inch or greater depth), placed in the last three years in Iowa.
Phase I Time Estimate: 9 months
Cost Estimate: $75,000

Phase II – In depth review of the good and bad performing pavements
Development of guidelines to emulate the good performing pavements
Phase II Time Estimate: 12 months
Cost Estimate: $150,000

Phase III – Follow-up study (three years after Phase II)
Review the performance of designs constructed using Phase II guidelines and companion ones that have not used those guidelines to determine the success of the implementation.
Phase III Time Estimate: 9 months
Cost Estimate: $75,000

5.03. *Investigation into Shrinkage of High Performance Concrete Used for Iowa Bridge Decks and Overlays* – Kejin Wang, Iowa State University; Iowa DOT, Office of Materials

Shrinkage is the top cause of concrete cracking. High performance concrete (HPC) bridge deck and bridge deck overlays often have a high risk of shrinkage cracking because of the high cementitious content in the concrete and the high surface-to-volume ratio of the structure; as the amount of cementitious materials in concrete increases, both the amount of autogenoues shrinkage and the portion of the autogenoues shrinkage in the total shrinkage of the concrete increase. This significantly contributes to bridge deck/overlay cracking. To reduce crack risk of these HPC concrete structures, it is important to understand the shrinkage behavior (such as shrinkage components, amount, and occurring time) of the concrete.

Recently, a large pool funded study has been conducted on internal curing of concrete in relation to reduction of concrete shrinkage cracking. However, little study has been performed on

concrete shrinkage in Iowa.

OBJECTIVES: To investigate the shrinkage behavior of HPC used for Iowa bridge decks and bridge deck overlays. The investigation will cover most commonly used Iowa HPC mixes and study the effects of concrete materials, cement and aggregate types as well as application of admixtures, on both autogenoues and drying shrinkage of concrete.

BENEFITS: Necessary information to accurately predict the strain/stress development in bridge decks and overlays produced by concrete volume change will be provided; material engineers and contractors will be provided with insight into any modifications on concrete material design and construction.

5.04. *Evaluation of Alternative Materials to Prevent HMA Stripping (Moisture Damage)* – Asphalt Materials Research Committee

Moisture damage to pavements is a continuing problem in Iowa. Moisture damage can arise from the selection of an aggregate, an asphalt binder, or in fact the lack of chemical compatibility between an aggregate source and an asphalt binder. Further, moisture damage can manifest itself through freeze-thaw cycling or hydraulic loading (e.g. trucks loading a saturated pavement that creates high hydraulic pressures and led to "stripping" of the binder from the aggregate). Recent research work has identified advanced methods for identifying HMA that is moisture susceptible. Recent field performance data has also identified materials commonly used to combat moisture damage such as some liquid anti-strip agents, not being as successful as historically thought. However, materials such as flyash and portland cement have been used successfully in other states to combat moisture damage, but are not used in Iowa. More recently developed liquid anti-stripping agents have also been employed elsewhere successfully too. The utilization of appropriate materials for use as anti-stripping agents would increase the life of HMA pavements.

Time Estimate: 18 months
Cost Estimate: $100,000

5.05. *Development of Performance Testing Criteria for HMA Design and QC/QA Testing* – Asphalt Materials Research Committee

Current field production tolerances allow alterations to job mix formula target values, and are acceptable based upon volumetric evaluation, but may alter mixture mechanical properties affecting expected performance and pavement service life. It is thought that additional evaluation of mechanical properties would lead to an improved mix design and acceptance program, for use and payment of materials. The mechanistic testing would create a more reasonable economic basis for evaluating mixes and reduce product risk as it relates to pavement performance. Flow number (Fn) testing has been identified as a preferred test to accompany volumetric (gyratory) mix design.

OBJECTIVES: The following four items are needed to implement mechanical testing of HMA in mix design and QC/QA testing:

- Mechanistic evaluation of key factors influencing mixture flow characteristics and Fn values.

- Identify Fn relationships related to specific material variations and define sensitivity of Fn in ranking mixtures tied to field performance.
- Guidance to impact current Iowa DOT mix design and QC/QA procedures. This includes defining improved procedures related to asphaltic mix design requirements and field production criteria/acceptance parameters.
- Development of training tools to enhance technology transfer including an executive summary with key graphics and PowerPoint presentations.

BENEFITS: The benefits of this project are expected to be significant for a few reasons. First and foremost, the outcomes of this project will assist in establishing a proposed performance test and associated performance criteria to accompany the current volumetric mix design procedure. Secondly, the performance test will be linked to field performance and be implemented for use in quality control/quality assurance testing. Overall, the identified mechanistic test criteria will be able to assess the intended field performance of mixtures prior to production, thus reducing risk related to performance, as well as being able to assess more accurately, production quality for payment. The outcomes of the research will improve the quality and longevity of hot mix asphalt pavements in Iowa, at a reduced level of risk.

Time Estimate: 24 months
Cost Estimate: $150,000

5.06. *Evaluation of Epoxy Patching Materials for Concrete Pavement* – Ed Bailey and Ron Loecher, Iowa Department of Transportation

Concrete pavement often has deterioration on the surface at joints but does not run deep into the pavement. This type of deterioration does not require full-depth patching, but is more extensive than can usually be repaired by the Iowa DOT Durapatch operations. There is a need for a type of patch that can bridge the gap between Durapatch and full-depth patching. Recently a number of small centerline patches were placed on IA-58 using an epoxy material. They appear to be performing well to date. There is a need to determine:

- Are there viable epoxy products that could be used by contractors in the patching or sealing business without the need for extensive training or huge equipment investment?
- Will these products hold up and will costs provide the benefit of smooth long life pavement?
- Can some simple to use expansion material be readily put over an existing crack to allow it to remain in the same location or are there products that would crack and hold up under traffic and weather?
- How extensive would patch prep have to be? Would the products hold up with the rounded corners that would result from a milling operation or would hand work be required?
- Do these areas gain strength quickly enough for a moving operation that does a significant number of miles in a day?

5.7. *Use of Recycled Concrete Aggregates in New Pavements* – Paul Wiegand, Iowa State University

OBJECTIVES: To develop a mix design process that recognizes engineering properties of the concrete pavement being recycled and incorporates various amounts of recycled concrete aggregates into the concrete while retaining the workability elements that are critical to the project. Due to the variables involved with use of recycled aggregates, defined mixes cannot be developed. The evaluation will identify which properties of the recycled aggregate are critical to the success of the mix. Criteria to be evaluated include the properties of the existing pavement, including the failure mechanism. In addition, the properties of the recycled aggregates, including

such characteristics as gradation, paste content, water absorption, freeze-thaw durability, and wear resistance (abrasion loss) must be ascertained.

BENEFITS: Once those elements are determined, a mix design process will be set up to identify the range for each variable that produces a concrete mix with the required workability. The research work involves working with Iowa recycled concrete aggregates for these mix designs.

Time Estimate: 24 months
Cost Estimate: $155,000

5.8. *Increasing the Stability of Unbound Shoulder Materials* – Jeramy Ashlock, Iowa State University

Coarse high-quality materials and recycled PCC and asphalt pavement are currently being specified for the construction of granular shoulders of Iowa roads. Proof rolling before placing the granular materials,along with moisture control during compaction, have helped improve performance but a few problems remain to be addressed. Due to the high porosity of the unbound shoulder material, water penetration into the underlying earth fill can cause erosion and decreased stability leading to unsafe conditions and increased maintenance costs. Significant savings in material and maintenance costs could be realized by replacing the high-quality aggregates with more economical ones if permeability and stability were adequately characterized first.
The stability of unbound shoulder materials will be studied by examining the relationships between permeability and strength under a range of compactive efforts. Suitable test sites will first be identified by consultation with county and state DOT engineers. In-situ permeability of shoulder materials will be measured and strength and stability will be evaluated via DCP and LWD and/or Clegg impact hammer tests. Samples will then be extracted from the test locations and the permeability and porosity will be studied for a range of compactive efforts in the lab. Draft criteria of gradation and relative compaction will be formulated to provide a balance of drainage and stability properties for unbound shoulder materials with the goal of reducing costs associated with materials, maintenance and safety.

Time Estimate: 18 months
Cost Estimate: $90,000

5.9. *Evaluate the Effect of Sample Curing on Quality Assurance Testing of WMA Mixtures* – Scott Schram, Iowa DOT Materials Office

Warm mix asphalt (WMA) technologies have been shown to affect properties of both the asphalt binder and mixture. Some technologies may reduce the high temperature performance grade of the binder. While these WMA mixtures may have exhibited lower initial indirect tensile strengths (IDT) compared to HMA control sections, a “curing” behavior has been observed in some field trials indicating IDT and PG grade may recover over time to levels similar to HMA. Similar results have been found in laboratory testing. WMA sensitivity to “curing” may complicate quality assurance efforts.

As WMA is implemented in Iowa, there is a need to quantify any curing effect and its ramifications on the ability of labs to correlate on testing. The objective of this study is to identify appropriate curing protocols for WMA sample preparation for both volumetric and mechanical testing. It is important to note that protocols which best simulate field conditions should be selected over those which simply match HMA testing results. Field tests of existing WMA pavements can be conducted. Both field and lab testing of new projects will be required.

Development of sample preparation protocols which simulate field conditions for routine QA testing of WMA mixtures.

Time Estimate: 18-24 months
Cost Estimate: $150,000

5.10. *Co-Product Uses from Bio-Fuel/Lignocellulosic Plants for Dust Control on Unpaved Roads* – Halil Ceylan, Iowa State University; Brian Keierleber, Buchanan County

Dust control is the number-one non-winter maintenance problem on unpaved roads in Iowa. The use of unpaved roads causes dust emission into the atmosphere, loss of road surface material over time, and frequent road surface deterioration in the form of ruts, washboarding, and potholes. Influenced by traffic volume, these problems can lead to high economic cost.

To reduce the loss of road surface fines in the form of dust, additives (dust suppressants) are applied to unpaved road surfaces to control fugitive dust generation and improve road surface stability. Ligninsulfonates or lignosulfonates – a resin derived from wood, is claimed to be the best dust control agent for the environment. Similarly, the application of by-products from local soy/ethanol/lignocellulosic bio-refineries may be a cost-effective and sustainable solution that could produce a road surface that is firm, smooth, dust free, and comfortable to drive. As Iowans become increasingly concerned about possible environmental damage associated with chemical dust control materials such as calcium chloride, the use of lignocellulosic residues is a feasible and viable alternative as it is biodegradable and contains no oil based contaminants.

5.11. *Alkali Content of Fly Ash: Measuring and Testing Strategies for Evaluating Compliance* – Scott Schlorholtz, Materials Analysis and Research Laboratory (MARL), Iowa State University

Sodium and potassium are the common alkali present in fly ash. Excessive amounts of these soluble alkalis can cause efflorescence problems and raise concern about the potential of the fly ash to mitigate alkali-silica reaction (ASR). Fly ash marketing agencies occasionally provide materials that just miss the criteria for alkali content given in IM 491.17. Since usage is only from a preapproved lists (certified sources) this leads to disputes that may be difficult to resolve. This is especially problematic when the alkali content of a given source of fly ash only changes by a small amount but the change causes the source to cross a specification limit. However, few studies have been performed that attempt to link the prescriptive limits with some type of real performance criterion. That is why research is needed.

OBJECTIVES:
- Review existing methods of fly ash alkali measurement
- Review models used to estimate alkali content of the various sources of fly ash commonly used in Iowa
- Ascertain how the measured alkali content of a fly ash impacts its ability to mitigate ASR

5.12. *Study Mix Proportion and Properties of Recycled Aggregate Concrete* – Kejin Wang, Iowa State University

During 1970s-1990s, Iowa conducted early research on recycled aggregate concrete. Greene County constructed a number of recycled pavements until 1994. In Greene County's projects, 100% coarse aggregate in a new concrete mix was replaced by the aggregate recycled from old concrete pavements. Although the recycled aggregate concrete had good performance, there is little research on comparison of properties of the recycled aggregate concrete with those of natural aggregate

concrete. Today, improvements in concrete technology, together with ongoing demand for reducing environmental impact, warrant further examination of this topic.

OBJECTIVES: To investigate potential mixes of concrete (made with deconstructed concrete as recycled aggregate) to minimize the environmental impact of pavement construction in Iowa. The previous experiences in recycled pavements in Iowa have provided a strong base for this proposed study, and these experiences can be beneficially used in the proposed study. The comparison of properties of recycled aggregate concrete with those of natural aggregate concrete will be conducted; results could broaden our knowledge and build confidence for proper use of recycled concrete.

The overall cost of recycled aggregate concrete may also be studied. All the results will be compared with those of natural aggregate concrete. Depending on the concrete workability and strength, the recycled aggregate concrete may be used for local street paving and/or structure foundations. The information obtained from the proposed study can provide a strong base for further study of recycled aggregate concrete, including field trials. The study is of great significance for sustainable pavement development in Iowa.

5.13. *Permeability Testing of Asphalt Pavement Surfaces* – Scott Schram, Iowa DOT Materials Office

Current density criteria are based on 7 cores. With permeability testing of asphalt pavement surfaces, this represents a method of non-destructive testing that can be successfully integrated into percent within limit specifications. Further, the construction of longitudinal joints and permeability measurements with a maximum criteria could be used to supplement or replace density measurements. Non-destructive testing would allow for same day results to be provided for subsequent integration into next paving day operations.

Development of permeability test criteria for quality control – quality assurance as well as the evaluation of longitudinal joint construction methods (tapered joint, butt joint, etc.).

Time Estimate: 18-24 months
Cost Estimate: $150,000

6. **Maintenance**

6.01. *Pavement Surface Rehabilitation Techniques for Poor Subgrade Conditions in Iowa* – Halil Ceylan, Iowa State University

For roads that exhibit large amounts of cracking and distortion in a short period of time, traditional repairs are often not practical due to high costs and extended construction time, as they require complete reconstruction of the roads with surcharge or removal of the unsuitable soils materials. In order to decrease the maintenance costs, less expensive solutions applied to the pavement surface are needed in Iowa. There are several recent techniques requiring removal of the pavement and base and which are not surface solutions. There is a need to develop repair procedures that only apply to the asphalt surface layer called "Surface Pavement Solution."

OBJECTIVES: To identify and evaluate various rehabilitation strategies and techniques that can be readily applied to the pavement surface course extending the life of the roadway. An integrated cost-benefit analysis will be performed for selecting the optimum Surface Pavement Solutions.

6.02. *Investigation and Evaluation of Iowa Department of Transportation Bridge Deck Epoxy Injection Process* – Mark Dunn, Iowa DOT, Research and Technology Bureau

There is a need to perform this treatment on 120-180 Iowa DOT structures annually. Currently this work is only performed by Iowa DOT bridge crews since there are not adequate specifications for contract treatment. Due to the narrow temperature range in which this treatment can be applied and the work load of the Iowa DOT bridge crews, it would be beneficial to have the ability to contract for bridge deck epoxy injection.

OBJECTIVES: This project will cover three main focus areas:
- Determination of the effectiveness and durability of epoxy injection
- Evaluation of the current state of the practice in the epoxy injection industry
- Development of procedures and specifications for epoxy injection.

PRODUCTS:
- Final report documenting the investigation and performance evaluation
- Manual of best practices and procedures for conducting epoxy injection projects: will be written for Iowa DOT bridge maintenance personnel performing the work in-house. It will be well illustrated including photos and diagrams when necessary.
- Training programs and/or video should also be developed
- Specifications for the performance of contract epoxy injection
- Project inspection guidelines for monitoring of contract epoxy injection projects

6.03 *Combination Snowfence/Right of Way Fence* – Bob Younie, Iowa DOT, Office of Maintenance

On many roadways maintenance forces attach lath or plastic snowfence to existing right of way fences to help control blowing and drifting snow. The practice is a very effective method to control blowing and drifting problems if the right of way area is of sufficient size to store the blown snow. The addition of the lath or plastic fence is not very attractive and is also a duplication of effort with the installation of two individual fences (Right of Way fence and snow fence).

7. **Pavements**

7.01. *Opening Strength for Concrete Overlays* – Paul Wiegand, Iowa State University

OBJECTIVES: To determine the relationship between the quality of the underlying pavement's support, the value of the bond strength between the overlay and the underlying pavement, if any, and the flexural strength of the overlay, as a means of determining the appropriate strength to open a new concrete overlay to traffic.

The project will involve lab and field work to evaluate the three-part relationship between the strength of underlying pavement and overlay through FWD testing, evaluation of bond strength obtained between the concrete and various surface types, and flexural strength of the new overlay.
Time Estimate: 24 months
Cost Estimate: $145,000

7.02. *Pre-Overlay Surface Mapping* – 2010 Iowa Research and Technology Transfer Committee of the CP Tech Center

As a result of project IHRB TR-600, "Improving Concrete Overlay Construction," certain items that could improve overlay construction and costs were identified. One such priority item was preoverlay surface mapping.

Control of concrete yield is greatly affected by the uniformity of the existing pavement surface. Knowledge of the elevations of the pavement edges, centerline, quarterpoints and wheelpaths is very helpful in the determination of the estimated concrete quantities and help prevent overruns. Surface mapping should be done prior to overlay design and overlay surface profile establishment to determine reasonable concrete quantities for bidding purposes. Currently the tried and tested manner of survey is with a total station and usually at 25 foot longitudinal intervals and three to nine shots across the pavement. This method is time consuming and can be expensive.

The following methods should be investigated:

- LASER CONTROL – A scanning laser that can be mounted on a framework that can sweep the highway gathering surface data by the square inch. In this case there is no interruption of traffic during the survey. Data would then be reduced in the office to the desired level of detail required.

- GPS – One millimeter accuracy done by an individual and data collection unit walking the various points of interest on the pavement. In each case the highway owner would be responsible for establishing a 1,000 foot interval control system as is done now by many agencies. A one to five mile overlay project with some vertical and horizontal relief is desired as the test location. The highway agency would then randomly check this work with rod and level or total station at a set frequency to determine the accuracy and repeatability of the individual systems.

Time Estimate: 6-8 Months
Cost Estimate: $80,000

7.03. *Concrete Overlay: Surface Milling of Asphalt Pavements* – 2010 Iowa Research and Technology Transfer Committee of the CP Tech Center

IHRB project TR-600, "Improving Concrete Overlay Construction," identified items that could improve overlay construction and costs. One priority item was surface milling asphalt pavements.

PROBLEM: Surface milling of concrete overlays removes significant surface distortions that contain soft asphalt, meets adjacent surface structure elevations and improves bonding where applicable. At times, milling of asphalt pavement has resulted in delamination of asphalt layers particularly those with insufficient asphalt tack between asphalt lifts in older pavements. When this occurs, particularly in concrete bonded overlays over asphalt, the asphalt does not function as a load carrying portion of the composite section, thus resulting in early pavement failures. Historically, milling depths are checked to meet asphalt lifts but cannot always be accomplished at the exact tack line. Current milling specifications do not limit the spacing of teeth for creating a milled surface for an overlay. Using widely spaced teeth and increased speed when milling do remove the surface quickly, but the effects on asphalt and potential delamination are not known. More closely spaced teeth and changes in speed may create a more uniform surface.

OBJECTIVES: To develop test method(s) to determine adequacy of existing asphalt pavement to

hold up under milling. Test protocol will be developed on the condition of asphalt and the adequacy of lifts to serve as a monolithic section in combination with concrete bonded overlay. Different milling drums will be examined to determine proper spacing of the milling teeth and speed to remove the surface quickly and minimize damage to existing asphalt. Milling drums research may already have been done by milling companies and could result in a synthesis from current publications. Results can be used to improve pre-milling protocol and specifications to help bonded concrete overlays to rely on existing asphalt pavements to carry some traffic loading.

Time Estimate: 12 months
Cost Estimate: $95,000

7.04. *Impact Of Curling and Warping on Concrete Pavement* – 2010 Iowa Research and Technology Transfer Committee of the CP Tech Center

The impacts of curling and warping on long term pavement performance are not well understood. There is a need to collect data from Iowa pavements to document the true degree of curling and warping. Following data collection, a mechanism will be developed based on models to study the problem and provide recommendations on how to minimize curling and warping. These will address both mix and pavement design along with construction techniques.

OBJECTIVES: Select existing concrete pavements of various ages, thickness and on top of various support systems. Selected panels will be identified and precisely surveyed at the center, corners and along edges. Such surveys will be repeated to include wet, dry, warm and cold conditions. Load transfer will be assessed between selected panels and their neighbors. Data of the mixture, construction details, and amount of curling and warping will be correlated against performance of pavement in terms of load transfer and cracking. Recommendations will be developed on the amount of curling and warping considered acceptable. Guidelines on achieving these values will be provided based on the literature.

Time Estimate: 24 months
Cost Estimate: $150,000

8. **Policy, Specifications, Administration, Economics, & Legal**

8.01. *Effective Training and Management of Multi-skilled Local Government Workforces* – Amr Kandil and Duane Smith, Iowa State University (Transportation Research Focus Group)

Workforces retained by county and city (local) governments are faced with many variations in work demands over the year. During the winter season, the main task performed by this workforce is the clearing of roads and maintenance for safety and accessibility, these sets of needs often determine the staffing levels. In the summer season, this same workforce performs maintenance and rehabilitation work on the public infrastructure maintained by the county or city. Another important task performed by this work force year round is maintenance of the county/city owned equipment by city employed mechanics and maintenance staff. The level of skill required can vary from very skilled to common labor. This variability in the level of skill of city/county workers creates a complex problem of effective management at the local level.

There is no clear guide on the training and continuous improvement requirements of the locally managed workforce. Such guidance is very important for updating the knowledge of these workers and for maintaining/enhancing their skill sets; the need to optimize the composition and skill level of the workforce for performing the tasks needed year round.

OBJECTIVES: This study will develop ideas for training programs for workforces employed by local agencies. These recommendations are to be developed by examining the training needs that county/city engineers foresee, and by evaluating similar training guidelines in other states. The project will also study variations in workload for optimizing the composition and skill level of workforces in local agencies. The study will then evaluate the suitability of these strategies for implementation in local government workforces.

BENEFITS: The main benefit anticipated from this study is the increased efficiency in the management of workforces retained by local governments, and an increased level of knowledge and skill-sets in these labor forces. This information can aid the Iowa LTAP in development of future training efforts as well as making adjustments to the current LTAP training programs (Iowa Roads Scholar Program as an example).

Time Estimate: 12 months
Cost Estimate: $75,000

8.02. *Investigating the Impact of Tax Increment Financing on Iowa's Secondary Road System* – Transportation Research Focus Group - Chris Albrecht and Shashi Nambisan, Iowa State University

Tax increment financing (TIF), has been used across the United States for decades as a tool for supporting community improvements and redevelopment. TIF is most often used by municipalities to utilize future gains in taxes to finance public infrastructure improvements that will ultimately create the gains. There is an anticipation of an inherent increase in the value of the surrounding real estate when a public improvement, such as a road or sewer extension, is made.

This increase in real estate value ultimately increases tax revenues to the municipality. Under TIF, this increase in tax revenue or "tax increment" is then dedicated to paying off the cost of the improvement. Although municipalities can capture more tax revenue under TIF strategies, other taxing jurisdictions such as counties do not see increases in tax revenue that may have traditionally flowed to them. In other words, while these strategies only capture increases in tax revenues for municipalities, there is a "loss" of potential tax revenue for counties. Furthermore, while tax revenues to counties do not increase, a county's expenditures may very well increase due to increased operating and maintenance responsibilities of local roads reflective of increased travel demand arising from greater economic activity and/or population. This research will investigate how the use of tax increment financing by local governments in Iowa has impacted funding available for the upkeep of the secondary road system.

Time Estimate: 9 months
Cost Estimate: $60,000

8.03. *Determination of Effectiveness and Potential Enhancements of the Statewide Urban Design and Specifications Program* – Kelly Strong and Amr Kandil, Iowa State University

The SUDAS Program contains design standards and specifications for several types of common urban public improvements, and it has been conservatively estimated that the creation, distribution, and adoption of SUDAS standards could result in annual savings of $16,000,000 in urban street construction alone. However, the actual benefits and cost effectiveness have not been determined The "SUDAS business model" may have potential benefits in areas besides urban public improvements. After several years of operation, it may be appropriate to assess the program effectiveness in regard to providing standard urban design and specifications, cost

benefits, and potential program enhancements and expanded services.

OBJECTIVES: This project will initially conduct a survey of the users of SUDAS manuals, including engineers from state and local agencies, consultants, and contracting industries, to determine the program delivery effectiveness, extent of use of the SUDAS Program, and the actual benefits (tangible and intangible) derived. The analysis will also include a determination of the cost effectiveness of the program since its inception.

This project will also conduct a needs analysis of state, local, and municipal engineers and related staff in order to identify future products and services that can best support their operations. The target products and services would be those that can produce cost savings and operational efficiencies, but may not provide economies of scale large enough to warrant investment by public agencies.

BENEFITS: Although final results of the needs analysis will provide the basis for final recommendations, potential new products and services may include coordinated procurement and commodity purchases, housing of digital archives and standards, integrated project management support (planning, scheduling, estimating), and creation of uniform quality assurance and quality control standards.

Survey results will be used to develop ideas for enhanced and expanded programs that could potentially be incorporated into the SUDAS structure or elsewhere. It is important to note that the enhanced and expanded programs that are subject to investigation in this study are those that will result in cost savings to Iowa public agencies. The study will also indentify costs of implementing additional services and potential sources of funding.

Time Estimate: 12 months

8.04. *Route-specific Traffic and Fiscal Impact Calculator for Iowa's Renewable Energy* – Nadia Gkritza, Inya Nlenanya and Bob Sperry, Iowa State University

A traffic and physical impact model has been developed to help assess the impact of additional ethanol/biodiesel plants on Iowa's secondary system as part of project TR-593, "Infrastructure Impacts on Iowa's Changing Economy" (expected completion 04/15). Inbound and outbound commodity flows in a plant are mainly based on ethanol/biodiesel plant capacity. The proposed study will extend the present impact calculator to include route-specific impacts. Route-specific commodity flows will be modeled for current and planned conventional ethanol/biodiesel plants and potential production and processing of cellulosic ethanol crops. The selection of counties for the route-specific commodity flow analysis will be based on the number of plants available and planned, years of operation, and availability of pavement management data and traffic count data. The traffic and physical impacts associated with plant operation will be assessed for road segments adjacent to plants, as well as road segments 3-5 miles away from plants. This will allow assessment of impacts on gravel road segments involved in inbound movements of feedstocks and outbound movements of final/by-products. Impacts on gravel roads are anticipated to be lower than those on paved roads, but would still contribute an increase in county expenditures. Geographic Information Systems (GIS) technologies will be utilized to provide a visual display of traffic and physical impacts on road network around existing and proposed plants.

BENEFITS: Quantifying the traffic impacts on specific routes around the plants and the

corresponding pavement deterioration can assist local governments to assess the fiscal impacts of Iowa's renewable energy as they relate to specific roads around existing plants as well as planned plants. The research team will also use the proposed impact calculator to explore the feasibility of alternative financing options to tax (or assess) the industry, such as a tax (or fee) per bushel of corn, gallon of product, or an axle-based weight-mile fee (associated with inbound and outbound truck shipments).

Time Estimate: 12-18 months

8.05. *Risk Mitigation Strategies for Operations and Maintenance Activities* – Kelly C. Strong, Jennifer Shane, Iowa State University

Previous research on construction work zone safety has found that moving operations represent the highest risk activity when both frequency of occurrence and intensity of loss are considered. The research further determined that using an integrated risk model that assesses risk over project life cycle could mitigate the risk of moving operations (among others) during the construction phase. Although designed specifically to examine risk and safety for construction projects, the finding that moving operations represent the highest risk construction activity suggests that the risk modeling process could be beneficially applied to operations and maintenance functions. The proposed research will examine how an integrated risk modeling approach could be used to reduce frequency and intensity of loss events (property damage, personal injury, fatality) during operations and maintenance activities. After proximate causes and risk severity have been identified, the research team will identify risk mitigation strategies that can be used within integrated teams to reduce the frequency and/or severity of losses during O & M activities.

Time Estimate: 12 months
Budget Estimate: $80,000-$100,000

8.06. *Digitize Archived Records of the Iowa Engineering Society Before They are Lost to Time* – Duane Wittstock, City of West Des Moines; Jeff Krist, City of Council Bluffs

There is a need to digitize archived records of the Iowa Engineering Society before they are lost to time. As an example, a copy of a discussion on special assessments for streets was just located in their records and helps establish the methods that many communities still utilize.

8.07. *Update the guidance information available for New County Engineers* – Roger Schletzbaum, Marion County Engineer

The special schools committee of the Iowa County Engineers Association has recently discussed the need for guidance for new county Engineers. It is not uncommon for it to take 2 years or longer for a new county engineer to become comfortable with all the aspects of County Engineering. There is a great need to shorten this time frame.

Over the years there have been various research reports to aid the county engineer in decision making. The 1994 *Iowa County Engineering: A Resource Guide for County Engineers* (Revised august 1995) and *Guidelines for County Engineering Decisions* (HR-369) are two documents that laid the foundation for helping County Engineers manage the Secondary Road system. Since that time many changes in decision making processes have occurred. In the past several years the ICEA service bureau has evolved into a key network for the county engineer, the federal guidance for projects has been revised, TPMS has been implemented, IMs have been updated and

numerous new environmental and administrative regulations have changed. Therefore there is a need to update the guidance information available for the new County Engineers.

OBJECTIVES: To produce a webinar that can be utilized to train new county engineers. The webinar could be in a modular format so that portions can be readily updated. Also a hard copy of a companion reference guide would be needed. The guide would cover all aspects of Secondary Road Department Management and reference many previous IHRB reports (such as the Road Maintenance Supervisors handbook, the Iowa Drainage Law guide and other documents) into one resource for use by County Engineers.

9. **Social & Environmental**

9.01. *Linking Highway Improvements to Changes in Land Use* – Richard Funderburg, & Miwa Matsuo, The University of Iowa

A previous study estimated the land use impacts of new highway construction in alternative contexts (urban extensions, exurban toll roads, and a small town bypass). Although a promising, initial step in applying quasi-experimental analysis to the question of highway infrastructure and regional growth patterns, two questions are still unanswered:

1. Are negative employment effects prevalent in small towns bypassed by new freeways?

The knowledge base regarding land use impacts in rural and small town environs is particularly limited. There is a great need to extend a focus to small towns and rural regions and perhaps our finding of a negative employment effect in the one town we studied will provide some impetus.

2. Are the changing growth patterns we can attribute to new highways entirely new growth (loss) or resulting from zero-sum shifts in the regional pattern?

We found that a new highway investment caused growth in areas gaining new access in an exurban setting, while a new investment imposed costs on a small town bypassed by a freeway in a rural setting. The methods in the previous research were unable to identify the companion effects in each case. Did other regions lose as a result of the exurban development projects?

Did other regions gain at the expense of the small town bypassed by the freeway?

Answers to these questions are needed to determine whether shifts have occurred and to clearly differentiate winners and losers in an effort to improve efficiencies in how we fund the building, operation, and maintenance of new highways for small towns and rural regions impacted by the highway bypasses constructed in the state of Iowa since 1990.

9.02. *Evaluating Vibration Impacts on Drivers and Operators of Road Construction and Maintenance Equipment* – Atul Kelkar, Mechanical Engineering Department, Iowa State University; Jerald Vogel, IVS; Bob Younie, Iowa Department of Transportation

Construction and maintenance are critical year round activities for city, county, and state Public Works Agencies/Departments of Transportation. Operators of construction and maintenance equipment often work extended hours and are subjected to trying, and sometimes hazardous, work environments. Drivers of these vehicles are exposed to undesirable vibration and noise conditions. Significant adverse health impacts can be sustained by a worker from such exposure in the work environment. Drivers of heavy vehicles who work continuously for more than a few hours at a time are subjected to potential health hazards as defined by the ISO Whole Body Vibration standard (ISO-2631).

The Iowa DOT and cities and counties in Iowa maintain large fleets of many types of vehicles several of which operate in rough environment on the nearly 114,000 mile public road network in the state. Examples include snow plows, heavy trucks, graders, maintenance trucks, transport trucks, off-road utility type vehicles, etc. The whole body vibrations experienced by operators of such equipment not only cause health injuries but also result in significant costs due to lost productivity, and workman compensation and litigation. The extended exposure to such adverse working conditions also causes long term hearing loss and related health issues.

Currently, there does not exist any data quantifying the vibration environment the drivers and operators of construction and maintenance vehicles owned by the state DOT, county, and city public works agencies are subjected to during their work hours. As a result there is no statistical data on short- and long-term health injuries, workman compensation costs, efficiency loss, and loss of overall productivity. It is therefore necessary to conduct a systematic study of the kind of work environment such operators/drivers are subjected to and whether the working conditions meet the ISO-2631 standards for Whole Body Vibrations. If working conditions do not lie within the recommended comfort and health index limits improvements need to be made to conditions.

OBJETIVES: To address the Whole Body Vibration (WBV) issue for drivers and/or operators of transportation agency vehicles/equipment. A two-phase approach is contemplated to address this problem.

Phase 1 of the project involves systematic evaluation of the WBV environment during operation of transportation vehicles and/or equipment. The WBV environment data collection and evaluation has to be done using recommended ISO procedure. The outcome of the project is expected to provide a quantitative assessment of WBV environment using standard norms such as health and comfort index. Analysis of the WBV environment data collected during the Phase 1 are expected to lead to recommendations for remediation of the undesirable WBV environment. Depending on the results of Phase 1, a follow-up Phase of the project will involve developing remediation strategies and solutions to improve the WBV environment for drivers and operators.

Time Etimate: 18 months

Budget Estimate: $150,000

10. **Bridges and Structures**

10.01 *Detection of Voids Below Approach Pavement* – Iowa DOT Office of Bridges and Structures

Due to various factors including bulking of granular backfill, inadequate drainage, and erosion, approach pavement at bridge abutments often is only partially supported by the sub-grade. The voids below approach pavement cause settlement and breakup of the approach pavement. One maintenance procedure is to fill the voids and raise the pavement to its as-constructed position. Although some voids are obvious; others are difficult to detect, and there is need for non-destructive methods to detect voids below the pavement. This proposed research will determine the best method for detecting voids and to purchase equipment for detection in the field.

10.02. *Evaluate the Need for Washing of Weathering Steel* – IA DOT Bridges Research Focus Group

Information indicates that salt plumes may be extending significant distances from the point of application. At the same time, weathering steel is being used more extensively in Iowa and their performance is reliant upon the formation and maintenance of a protective patina which is negatively impacted by chlorides. The degree (including location, rate of accumulation, etc.) and location of contamination in existing Iowa bridges needs to be determined. This investigation needs to provide policy recommendations on the frequency and location of washing.

OBJECTIVES: To determine if chloride contamination above the critical threshold is occurring on Iowa's weathering steel bridges and at what locations. Further, this work should establish the frequency with which washing may be needed to prevent deterioration due to corrosion.This information will be used to make recommendations for the development of a maintenance policy.

10.03. *Totally Precast Bridge Piers for Accelerated Construction* – Jon Rouse, Iowa State University

The benefits of accelerated construction techniques for all components of bridges and complete bridge systems are widely recognized. One of the most promising means of achieving advances in this field lies in developing designs employing prefabricated or precast components. Specifically, piers need a focused research effort to bring precast substructures into common use in Iowa.

A recent study, "Feasibility Investigation of Segmentally Precast Bridge Piers for Accelerated Construction," has made significant progress in demonstrating small-scale prototypes of precast pier columns that, in many aspects, have superior structural performance to conventional reinforced concrete columns. Initially, this research would focus on readily constructible details for modular, precast pile caps and pier caps to develop a totally precast pier system; once these details have been developed, one or more full-scale field demonstration projects would be selected for full-scale testing of the elements developed in the laboratory.

The research should deliver a set of design drawings and specifications for modular precast piers that could be used in new bridge construction. Once the demonstration bridges are constructed and the pier monitored for a period to verify adequate performance, a set of design procedures for each component for use by practicing engineers would be developed. Finally a set of standard details and specifications would be developed to aid practicing engineers in design.

Direct construction costs can be significantly reduced, but even greater savings in indirect costs associated with traffic delays, work zone safety, and environmental impacts truly distinguish this research as a long term opportunity for cost savings to the state.

10.04. *Adapting Accelerated Bridge Construction (ABC) Best Practices for small Scale Projects with Local Jurisdictions* – Iowa Department of Transportation, Bridges & Structures Focus Group

Most of the techniques available for ABC are designed for large, complex bridges with heavily traveled roadways. Many of these techniques are applicable to smaller bridges with local labor and equipment, but may need to be modified or adapted in some way. There are approximately 20,700 bridges in Iowa which fall under local jurisdictions—clearly, ABC technology can benefit a wider range of project sites than those where it is currently being utilized. Concerns of local jurisdictions include such things as: Improved worker safety; Minimized traffic disruption and duration of detours; Simplicity; Tradeoff of construction cost vs. time; Cost effectiveness.

OBJECTIVES: Develop appropriate details and construction techniques which satisfy the factors identified in the problem statement. The development of precast or prefabricated bridge elements may need to precede this project or be developed as part of the adaptation of best practices.

Develop useful cost estimating procedures and guidelines to allow the local agency to make economic decisions and comparisons to conventional construction methods. This model will need to incorporate both direct and indirect costs in order to allow bridge owners to make the best decisions. A user's manual will be developed to incorporate the above described tasks.

Time Estimate: 36 months
Cost Estimate: $300,000

10.05. *Improving Accuracy of the Deflection and Camber Predictions for Prestressed Concrete Bridge Girders* – Ahmad Abu-Hawash, DOT Bridges & Structures; Prestressed Concrete Producers

During the construction of bridges comprised of prestressed concrete girders, the Iowa DOT has observed that the predicted girder cambers are much larger than those observed in the field at erection. This discrepancy has often caused the top flange haunch of the girder (used to adjust vertical elevations of the girder with respect to the final bridge roadway grade) to differ from the design, resulting in unplanned placement of reinforced concrete. Adding more concrete in the field in this manner increases the bridge dead load, which leads to increased costs and quality control issues of the finished bridge, including composite action between the girder and the bridge deck.

The source for the variation between the design predictions and measured cambers at erection is not well known, although it is likely that a number of different parameters contribute to the cause including, but not limited to: 1) girder material properties due to the change in concrete mix design over time; 2) precasting (fabrication) process; 3) support conditions while stored temporarily in the precast plant before delivery to the bridge site; 4) thermal effects; etc.

The precasters and both the State and Local Systems in Iowa are familiar with the problems stated above and generally support efforts to address these issues. A systematic study can identify the effect that these and other parameters have on the prediction of camber to alleviate the associated problems caused in the field by excessively small cambers experienced for precast girders.

OBJECTIVES: To quantify the camber of prestressed bridge girders through measurements made, and pertinent existing data evaluated, during the fabrication and erection of the girders and the bridge. In meeting this objective, it will be possible to develop more accurate predictions of girder camber at erection and/or increase the camber of the girders if this is desired.

The following tasks are proposed for this research project:

- Obtain camber records (and material property records) and material properties from precasters and from the Iowa DOT
- Identify multiple girders from multiple bridges to be monitored from the fabrication state to final erection
- Monitor camber in girders identified in Task 2 at precasting plants and at erection
- Evaluate and correlate observed camber, material properties and other data obtained in previous tasks to identify potential causes of variation in camber
- Develop recommendations for better prediction of camber, including possible modifiers to the existing design procedure used by the Iowa DOT

11. **Traffic & Safety**

11.01. *Temporary Traffic Control Plans for Local Agency Improvements* – Tom McDonald, Iowa State University, CTRE

Construction and maintenance of public improvements generally adversely affect road and street users, even if the facility is closed to traffic during the work. Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD) strongly recommends that a sufficiently detailed temporary traffic control plan be developed for all road and street projects. In addition, the Iowa DOT Office of Local Systems has listed broad guidelines for traffic control on local agency improvements. Local agency project plans, whether developed by the agency or by a consulting engineer, commonly include a plan for accommodating local traffic during construction. This is generally described as a temporary traffic control plan (TTCP). However, the scope and detail of these TTCPs can vary significantly.

OBJECTIVES: To develop broadly scoped recommendations for a model TTCP including recommended contractor compensation. Extensive detailed layouts of TTCPs will not be included, however, examples of basic temporary traffic control layout for short term maintenance and utility work as well as long term street closures will be featured. The final product will be included in the Iowa Statewide Urban Design and Specifications (SUDAS) Design Manual. An advisory committee will be selected and will consist of consultants, cities, contractors, and selected offices in the Iowa DOT.

11.02. *Perform an In-depth Study of Low Volume Rural Road Crashe*s – Tom McDonald, Iowa State University

A review of crash data in Iowa reveals that a high percentage of serious crashes occur on lower

volume rural roads, however historically, most emphasis for safety improvements have been focused on higher volume roadways. This study would involve an in-depth study of all fatal and major injury crashes that have occurred on low volume (<400 VPD) rural roads in Iowa, including unpaved roads, to determine if any commonalities (geometric features of the roadways, structures, driver age, seat belt usage, alcohol involvement, road surface, etc.) exist that could be addressed through focused safety programs. Since Iowa's network of this type of roadway is extensive, identification of features contributing to these crashes would be instrumental in developing safety programs to mitigate this serious safety concern. Those programs could include enhanced enforcement, specific driver education topics, and engineering improvements.

11.03. *The Effect of Roadside Vegetation on Frequency of Deer Collisions* – Kirk Henderson, The University of Northern Iowa, Native Roadside Vegetation Center

The frequency of deer collisions is a factor of traffic volume, speed, and due to the large deer population. But some people use potential for increased deer collisions as an excuse for not planting native vegetation. Is native vegetation responsible for the presence of deer in the r-o-w? Preliminary research indicates mowing attracts deer to the r-o-w to graze new growth. Does taller grass give motorists less time to react to deer or does it make deer less likely to bolt into traffic? Since the state's native planting locations are already on computerized maps, settling this may be as simple as overlaying those maps with locations of deer carcass collections.

Time Estimate: 12 months

11.04. *Shielding Median Bridge Piers with High Tension Cable Guardrail*: *Iowa's Experience* – Chris Poole, Iowa DOT Office of Design

With the less than stellar performance of the w-beam bullnose guardrail treatment, the Iowa DOT began shielding median bridge piers with high tension cable guardrail in 2005. Since that time, many of the bullnose systems have been replaced with high tension cable systems. While these new systems seem to be functioning well, an in-depth analysis of their crash performance and of the DOT's maintenance experience with them has yet to be performed.

OBJECTIVES: To provide an overall assessment of the performance of high tension cable guardrail used to shield median bridge piers. This will require the collection of construction, maintenance, and crash records for each of the installations. Additional information may be obtained by conducting interviews with maintenance personnel, law enforcement, and high tension cable guardrail manufacturers. The assessment should include: average installation cost, average repair cost, breakdown of crash performance, and analysis of maintenance experience.

This research will identify any recurring problems with collision performance or maintenance of high tension cable guardrail systems used to shield bridge piers. Results will highlight the need for any modifications to the current guidelines which could increase the system's crash effectiveness and/or reduce costs. This will also allow the DOT to determine whether the investment in this technology has been worth the expense, and whether continued or expanded implementation of these new systems is warranted.

11.05. *Improving Traffic Safety by Using Digital Videography to Inspect, Monitor and Manage Temporary Traffic Control Installations in Transportation Work-zones* – Edward Jaselskis, Kelly Strong, and Tom McDonald, Iowa State University

On average there are 980 fatalities per year in roadway work-zones in the United States. In Iowa, there is an average of 5.3 deaths per year and an average total of 366 total work-zone crashes per year. Improvement of temporary traffic control (TTC) installations is one method to reduce the number of motorist crashes in work-zones. Digital videography offers an innovative management information system to review and evaluate the current state of practice and thereby improve the efficiency and quality of TTC inspections programs across the nation's transportation network.

This research will demonstrate how TTC safety inspectors, remotely located at central offices, using digital videography can periodically review the installation of TTC devices and remotely monitor the maintenance of TTC over the course of the improvements without ever being physically present within the work-zones. From a risk management and safety compliance viewpoint, it is important to transportation agencies that verification is completed to assure reasonably accurate monitoring and documentation of TTC conditions. Individuals with extensive knowledge and professional experience in TTC are ideal reviewers of project traffic control daily diaries. Such experts can improve work-zone safety and traffic mobility, but there are insufficient numbers of trained experts to efficiently monitor the large number of active transportation work-zones at any given time, especially if on-site inspections are to be completed as part of this review.

Digital videography reduces the cost and time hurdles of on-site inspections and therefore increases the percentage of work-zones able to be individually reviewed with limited agency resources.

Developing a process for remote TTC inspections will benefit a number of parties, including the traveling public, the construction industry, transportation system agencies, and transportation researchers. The benefit of to the traveling public is three fold. The first aspect is fewer people being injured or killed in work-zones. The second benefit is the driving ease and personal comfort provided to drivers when traveling through work-zones with properly installed and well maintained TTC. The third benefit is a reduction in economic losses and road user costs resulting from work-zone crashes.

This could allow IADOT, and other transportation agencies, to improve and refine their TTC standards. Additionally, remotely executed inspections employing videography can provide a simple way for experts at the transportation agency to periodically review TTC installations without the cost and time to travel to the work-zone location. As a broader impact of this research, the IADOT and others may find it helpful to use virtual project tours for remote project management and inspection of other construction-related activities.

Budget Estimate: $34,109
($31,760 in matching funds has been obtained from the Midwest Transportation Center)

11.06 *Evaluation of Cross-Centerline Crashes in Iowa* – Shauna Hallmark, Iowa State University/InTrans

Cross-centerline crashes make up only a small percentage of crashes on divided roadways but frequently result in severe injuries and fatalities. In Iowa, 7.7% of rural crashes (2006) were indicated as having "crossed centerline" as one of the first two sequences of events for one of the vehicles in the crash.

OBJECTIVES: To provide tools to reduce the frequency and severity of cross-centerline crashes in Iowa. To accomplish this, the following main activities are proposed:

- Identify roadway (design), operational, environmental, and driver factors and combinations of factors that contribute to the frequency and severity of cross-centerline encroachments and crashes.
- Identify and summarize existing knowledge, which will entail conducting a standard literature review, drawing on team expertise, and surveying states and other agencies. It will also be necessary to evaluate the relationship between contributory factors and cross-median crashes. Many factors can be evaluated through a traditional crash analysis. However, some factors will need to be explored in a different manner. We expect that it will be necessary to evaluate median encroachments as surrogates for cross-centerline crashes. In some cases, a particular factor can only be evaluated through qualitative analysis such as use of expert opinion.
- Identify a range of potential countermeasures, such as centerline rumble strips, suitable for addressing these contributory factors. This will entail identifying countermeasure, determining their effectiveness and cost, and determining which factors they are most applicable to.
- Summarize results

Time Estimate: 12-18 months
Cost Estimate: $65,000

11.07 *Evaluation of the Effectiveness of Rural Flashing Intersection Beacons* – Shauna Hallmark, Iowa State University/InTrans

A number of agencies in Iowa use overhead flashing beacons at rural intersections to provide advance notification to drivers. In some cases, overhead flashing beacons may be used instead of intersection lighting if lighting is serving as destination lighting. However, the effectiveness of rural flashing beacons has not been well quantified. This project would evaluate the impact of these beacons on crash history at rural intersections.

Time Estimate: 12-18 months
Cost Estimate: $75,000